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City Planning Approach for Enterprise Information System

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Abstract

Recently, a framework to consider the overall architecture of enterprise information systems (EIS) such as the Enterprise Architecture (EA) has gained increasing popularity in Japan. In this paper, we propose a city planning approach for an EIS comprised of EIS architecture and an EIS Scenario. Our proposed approach leverages the methodology of city planning in civil engineering to provide a framework for portraying an EIS.
First, we illustrate an EIS architecture that refers to the architectural description provided by IEEE. Architecture can be described as viewpoints based on stakeholders' concerns. We focus on three specific viewpoints: "structure," "part and whole," and "ins and outs." To achieve an aggregation of each project and stakeholder concern included in an EIS, we discuss an EIS Scenario that includes a migration plan in terms of a mechanism of program management. Second, we discuss the validity of our framework and discuss its applicability.
Our framework is intended to offer management and CIOs a useful methodology for designing EIS architectures from a top level view of the enterprise that takes into consideration several stakeholder viewpoints. Our framework is intended to provide a metaphor for visualizing otherwise unseen EIS architectures.

Keywords: EIS City Planning Approach, Enterprise Information System, EIS Architecture, EIS Scenario

1. Introduction

The Federal CIO Council (1999) has proposed a Federal Enterprise Architecture Framework intended to help architects, the Agency Head and the Chief Information Officer (CIO) develop, maintain, and facilitate the implementation of top-level enterprise architecture for federal enterprise systems. In Japan, the IT Associate Council sponsored by the Ministry of Economy, Trade and Industry (METI) published an interim report on enterprise architecture (EA) in November, 2002, followed by a design guideline for EA in December, 2003, which was based on the Federal Enterprise Architecture. With these activities in the background, firms have become increasingly interested in EA. Since most large-scale enterprise information systems are composed of independent, heterogeneous systems developed at different times by independent teams, they often have a complicated structure of disparate architectures. Planning an architecture for such aggregate information systems thus requires a comprehensive approach different from that taken when planning an architecture for individual systems.

Zachman's framework (Zachman, 1987) is a well-known IT architecture framework for enterprise systems. While this structure has been successfully applied, it focuses on the development of large-scale systems without providing a comprehensive view of Enterprise Information Systems (EIS). Other groups have proposed similar frameworks or concepts with the same fundamental focus. Following Zachman's framework, for instance, the RM-ODP standard of ISO and the Open Group Architecture Framework (TOGAF) were proposed.

In a report arguing that "the failure to distinguish between architectural 'blueprint' level issues and macrocosmic 'city planning' issues" is the primary reason that IT architecture has not worked in the past," the Gartner Group (Schulte, 1997), has advocated a city planning concept meant to present an entire picture of EIS. According to the Garter Group report, "The design of a building or an application system is an architectural issue; one set of blueprints can describe the structure in detail because there is one developer." This concept has become known as the city planning concept of IT architecture, in which an analogy is drawn between EIS and cities. Other groups (IBM 1999) have proposed similar city planning concepts using the same analogies.

According to Ross (2002), in an article discussing her four stages maturity model of IT architecture, while "the city plan concept has given birth to a breed of IT architecture", it often provides "only the technologist's perspective of the relationship between IT and business processes." Ross's criticism of IT city planning models focuses on the idea that they have not fully exploited IT capabilities. "Accordingly, the city plan metaphor has failed to capture the strategic potentials of enterprise IT architecture." Rightly, Ross's point of view calls attention to "the objectives of the IT architecture, specifying what the architecture enables the business to do."

We propose that the "EII Meta-Model" (Namba & Iijima, 2003a, 2003b) offers a more integrated information infrastructure framework for EIS. We have also proposed the EIS City Planning Approach (Namba & Iijima, 2003c). Our framework differs from the city planning concept that Ross criticized insofar as it provides classified viewpoints to describe particular architectures, rather than discussing architecture in general. The purpose of our classifications is to clarify the needs of stakeholders.

In this paper, we aim to describe an EIS architecture framework based on an aggregation of architectures that draws on the similarity between cities and EIS. Our EIS City Planning Approach is comprised of both an EIS architecture and an EIS Scenario. First we illustrate an EIS architecture with reference to the architectural description provided by IEEE Computer Society. We then discuss an EIS Scenario that includes a migration plan in terms of a mechanism of program management to achieve an aggregation of each project included in an EIS. Second, we discuss the validity of our framework and its applicability as a workable approach to realizing EIS along architectural lines.

2. EIS City Planning Approach

2.1 Enterprise, Architecture and EIS architecture

In their report on Federal Enterprise Architecture, an enterprise is defined (CIO Council, 2001) as "an organization (or cross-organizational entity) supporting a defined business scope and mission." METI uses identical definition. This definition, however, seems a bit ambiguous for the firm that adopts the business unit system since the definition is applicable to the whole company or to a single business unit. The meaning of "optimizing the overall systems (METI, 2003)," in other words, varies depending on the structure of the enterprise. To address this ambiguity, we define "enterprise" as the highest level of a business domain governed by top management. When the lower business domains are highly independent and the business relationship to upper level is weak, we can also define the independent business unit as, substantively, an enterprise.

The term “architecture” traditionally refers to an architectural structure such as a building or a bridge, and it has been used in the fields of computer science and information systems to form an analogy between civil and systems engineering. Sewell and Sewell (2001), for instance, noted the similarity between architectural structures and software. In our previous work, we applied this similarity to devise an analogy between a city and an EIS structure. As a city is an aggregation of buildings and other constructs, an EIS is composed of independent information system structures. We describe EIS architecture as an architecture of architectures.

For the purpose of drawing out the analogy, we have referred to IEEE Std 1471-2000 (IEEE Computer Society, 2000), which illustrates an architectural description using a class diagram showing the relationship between stakeholders, concerns, viewpoints, and views. We modified the IEEE diagram by arranging some elements in line with the nature of EIS, changing the definition of terms, simplifying the architectural description, and describing the class diagram (shown in figure 1).

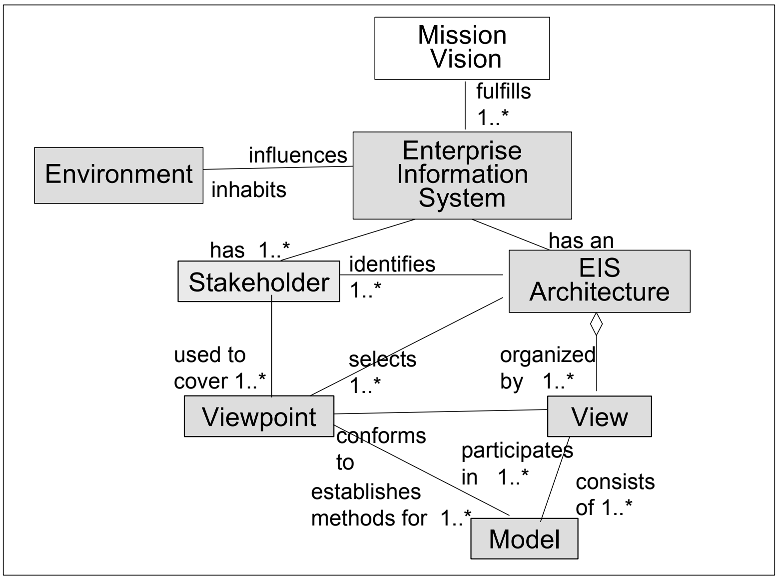

Figure 1 Conceptual model of EIS Architecture

An EIS that fulfills the vision or mission of a firm takes into account both EIS architecture and stakeholders. Planning an EIS architecture, in other words, requires identifying stakeholders, selecting one or more viewpoints, and organizing the plan by views. A view conforms to a viewpoint and may consist of one or more model(s). Each model is established with a method defined by the corresponding viewpoints. A viewpoint, in turn, determines the associated modeling method and analysis techniques. The architect’s role is to design the EIS comprehensively from viewpoints defined according to the concerns of stakeholders.

Generally, stakeholders of information systems include IS staff, end users, and management (Ewusi-Mensah, 1997). RM-ODP (Putman, 2001) states, “Stakeholder is a term to represent any customer, user, owner, administrator, acquisition authority, or program manager.” According to IEEE Std 1471-200, the stakeholders that architects should consider when they define an architectural concept are systems users, systems owners, systems developers, and systems maintainers.

In the context of EIS, stakeholders are management members, CIO, local management, EIS architects, and other persons who have an architectural concern in the outcome of the EIS. Insofar as an EIS must connect customers (business to customer electronic business: BtoC) and aligned or partner companies (business to business electronic business: BtoB), the definition of stakeholders may be extended to include users of each information system in the EIS, such as customers, allied companies, and business partners. Moreover, when defining their stakeholders, firms benefit from considering the influence of corporate social responsibility (CSR). All of these factors are included in the EIS environment, and have a direct or indirect effect on each stakeholder through the EIS.

2.2 As-is, to-be and live-to-be Models of EIS Architecture

An EIS must meet the vision and/or mission of the enterprise, as shown in the top box of the class diagram in the figure 1. When a firm plans an EIS, the architect must map out the vision in the EIS to-be architecture, which becomes a blueprint to portray the future enterprise system. Generally, it may be difficult to migrate from an existing EIS architecture (EIS as-is architecture) to this ideal future architecture (EIS to-be architecture) directly because of such constraints as human resources, technological capabilities, the current status of effected information systems, the social environment of a firm, and CSRs. With these constraints, a firm is tasked with setting the actual target outcome for the EIS architecture (EIS live-to-be architecture). Since the nature of an EIS live-to-be architecture varies with time, the architect has to periodically review and redesign it, if necessary, in accordance with actual performance, degree of environmental change, and the progress of technologies.

2.3 EIS Scenario

"Development plan" and "zoning" are two major processes to be addressed to realize a city plan. A development plan is a long-range project master plan that shows a target feature of a city sets and a directionality for urban policy. In this sense, a development plan is a measure intended to solve issues proactively. Zoning is a rule or regulation enacted to control land utilization, which classifies an area, delineates usage of land, or prohibits a particular land usage. Typically, zoning aims at realizing land utilization in accordance with the characteristics of an area. Thus, zoning may be characterized as a passive planning technique. By analogy, a development plan corresponds to a mid-to-long-range plan focused on realizing a live-to-be EIS architecture, while zoning corresponds to a migration plan intended to achieve an EIS live-to-be architecture iteratively. Zoning formulates the EIS service portfolio with the aim of creating an integrated infrastructure and executes this portfolio in accordance with regulations or pre-existing standards, which are analogous to a land utilization program or a building code.

City planning typically includes two methods of execution: new development, which may develop, for instance, a neighborhood or shopping center on vacant parcels, and redevelopment, which develops on land that holds old buildings and old infrastructures. Redevelopment applies to, for instance, slum clearance, and includes scrap-and-build, rehabilitation, and conservation approaches. The goal of rehabilitation is to repair a building or infrastructure while maintaining an existing community, while conservation aims at inhibiting deterioration. Redevelopment methods are characterized by the utilization of present infrastructures and assets, which are converted iteratively. Just as an EIS city planning approach necessitates consideration of cost and time, firms have to select a suitable method within the given situation and promote the project appropriately.

An EIS Scenario implies a program management technique enacted at the level of the whole firm. It includes both a long-range and short-range perspective while it envisages both the impact of the architecture of each information system and the likely life cycle phases of each project with an emphasis on future optimization. In the words of Ewusi-Mensah, "the most obvious advantage of using the phased-lifecycle approach is to help the project team realize what the deliverables for each stage are and to know if they have been satisfied. The iterative nature of systems development notwithstanding, the phased-lifecycle approach has been instrumental in helping to manage and control the development of large, complex systems successfully."

Further, an EIS Scenario includes a migration plan that delineates the EIS strategy based on the given enterprise business strategy. The target migration is to an EIS live-to-be architecture that maintains consistency among all information systems in the enterprise. An EIS Scenario also takes into account program management, which includes EIS activities such as maintenance, systems monitoring, and operation tasks. As a framework, an EIS Scenario includes processes, activities, and tasks of software products. Further, it has to cover the entire life-cycle-model, from the design phase to the disposal phase.

2.4 EIS City Planning Approach

Our EIS City Planning Approach provides a methodology for designing an EIS architecture as an architecture of architecture, for planning an EIS scenario, and for performing the migration required to realize this scenario.

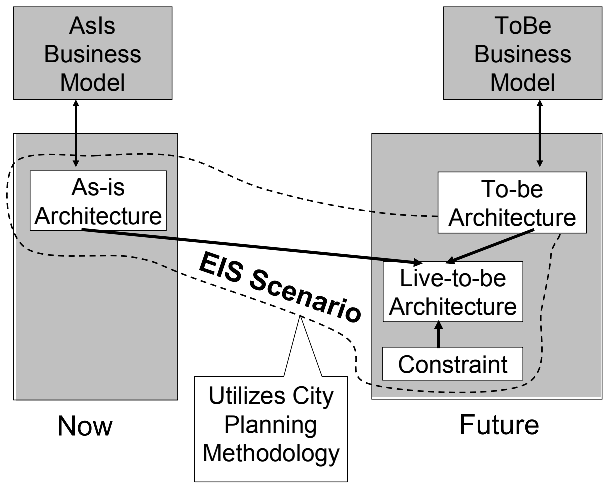

Figure 2 Framework of EIS City Planning Approach

Figure 2 shows the relationship between strategy, EIS architecture, and EIS Scenario. LiveToBe architecture is a target architecture from both AsIs and Tobe that takes into consideration various constraints surrounding the actual EIS.

3. Three Viewpoints of EIS Architecture

As figure 1 shows, architecture selects viewpoints. Since viewpoints determine associated modeling methods or analysis techniques, it is necessary to select a proper viewpoint for describing a projected EIS architecture. Every architectural viewpoint is a description intended to capture aspects of the planned objects (e.g., the drawing of a plane view, side view, and plumbing). In EIS architecture, a viewpoint describes the structure of information systems, and includes such modeling techniques as an entity relationship diagram (ERD) or a class diagram. Accordingly, viewpoints focus on each aspect of the system and are orthogonal each other. A view, meanwhile, is an actual figure based on a viewpoint. Consequently, architecture is described as an integration of views. We portray EIS architecture from three viewpoints (shown in figure 3) based on the concerns of stakeholders.

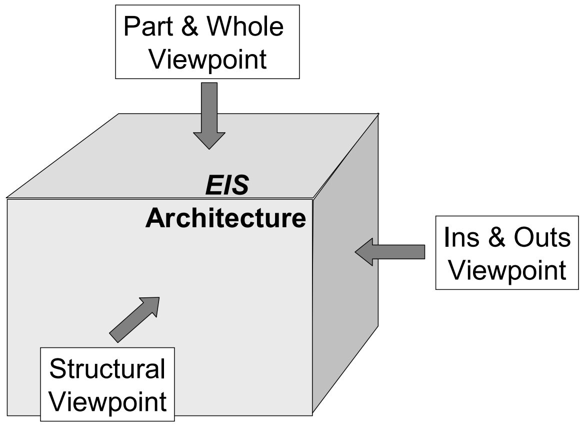

Figure 3 Three Viewpoints of EIS Architecture

3.1 The Structural Viewpoint

A city plan may overarch two domain types. The civil engineering domain focuses on developing a social infrastructure, and the architectural engineering domain aims at redeveloping an urban area. An additional domain that takes precedence over both, meanwhile, is the social environment. These three domains compose a layered structure. Analogously, EIS architecture has the structural viewpoint shown in figure 4. The top layer is the business layer, which is followed by the information services layer and the integrated infrastructure layer. These layers have a relationship such that the upper layer drives the lower layer and the lower layer enables the upper layer.

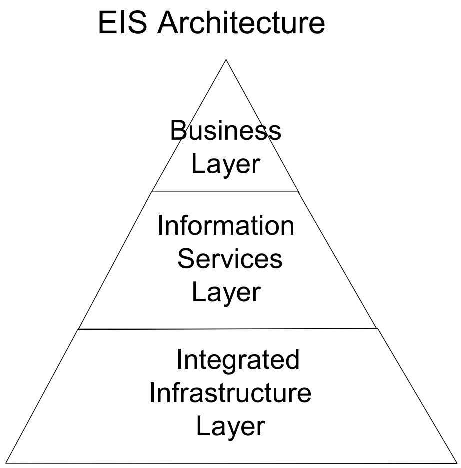

Figure 4 The Structural Viewpoint

As the business layer is generally complex in nature, it is often difficult to describe it as a whole picture. The viewpoint from the stakeholder’s concern, however, can be rendered by a modeling technique such as data modeling or business process modeling. The information service layer is an information services portfolio composed of an aggregation of applications that consists of data and process specifications and/or information services. The integrated infrastructure layer includes common service and maintenance, monitoring and systems operations on the systems platform, middleware, DBMS, common interfaces for both intra- and inter-enterprise connections, and gateways (Namba & Iijima, 2003a, 2003b).

3.2 The "Part and Whole" Viewpoint

A city plan serves to mediate between the concerns of individuals or a specific area as a part and the public as a whole. Analogously, an EIS architecture, if a firm employs a business unit system under a decentralization policy, serves to regulate the relationship between a business unit and the corporate whole. Figure 5 shows the relationship of benefit between the part and the whole. Development in the right-upper region (first quadrant) and the left-lower region (third quadrant) does not generate major issues or conflict, because both a part and a whole, obeying market law, share a mutual interest. For the development of a specific area of the left-upper region (second quadrant), however, it is often the case that the part can benefit while the whole receives a deficit. In case where the whole receives the deficit for the benefit of the part, some regulation or rule is required to compensate the whole. Case where the fourth quadrant receives the deficit often lead to Not-In-My-Back-Yard (NIMBY) type conflicts, and a plan should be executed with some incentives to appease the affected part.

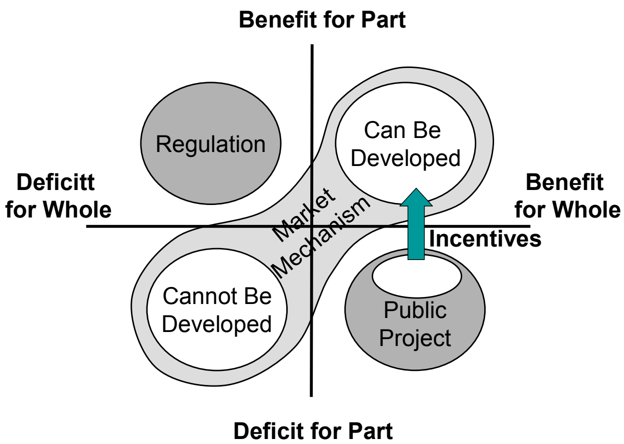

Figure 5 Viewpoint from Part & Whole

3.3 The "Ins and Outs" viewpoint

Histories of cities may be summarized as histories of compromise between restricting the concentration of population and the expansion of populated of urban areas. In other words, cities are forever tasked with the question of how to sustain the city area within manageable parameters. Similarly, the requirement for collaboration and alliance between firms accelerates the expansion of operational boundaries beyond the original boundaries of the enterprise as a legal entity. Simultaneously, the boundaries of an EIS also expand. Figure 6 shows the relationship between a firm's boundary between of legal entity, information systems, and business activity. Outside of or on these boundaries, competent authorities regulate the activity of firms, while the community and/or society require corporate social responsibility (CSR). Customers, business partners, customer companies, and vendors are connected with some business activity through BtoC or BtoB. The boundaries of business activity and information systems cover a wider area than that of legal entity, and do not coincide each other because of their different natures and responsibilities. Even within firms, the necessity to collaborate beyond the boundaries of each individual application or information system is rapidly spreading. As a result, not a few firms are burdened with the hardship of maintaining spaghetti structure of information systems.

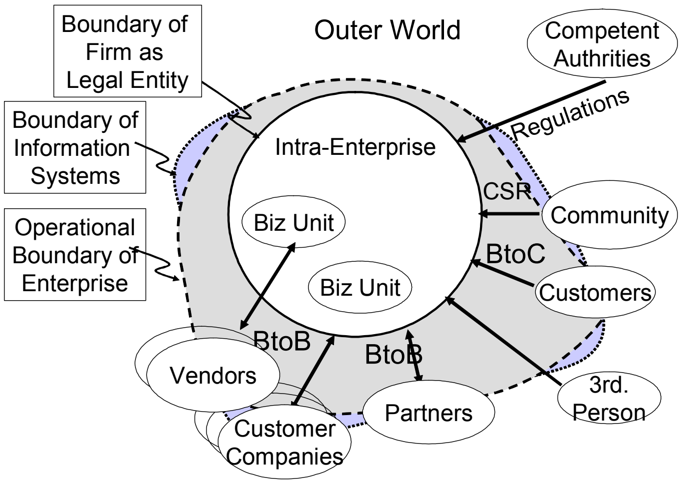

Figure 6 Ins & Out Viewpoint

In such a case, each structural layer can have a different boundary. For instance, in an integrated infrastructure, the boundary of an information infrastructure as a firm's asset may differ from the range of operational responsibility. The architect therefore has to design an intra- and inter- enterprise structure of systems collaboration and decide whether it should be implemented in the information service layer or the common information infrastructure layer. This decision should be made from a point of view that takes into account role sharing between the part and the whole as well as Ins & Outs. Such factors are closely related to the organizational architecture of the firm.

4. Discussion

4.1 Concerns for Stakeholders

During the period of legacy systems, the users of the systems were primarily employees, and infrastructures were assets internal to the firm. The situation, however, has changed as firms increasingly employ BtoC models and as customer use of firm systems has become a primary source of profit. Thus, both the user and the management domain of firm infrastructures are expanding to an area beyond the firm's boundaries. Moreover, the objectives of information systems now lie outside when firm's own systems, as is the case, for instance, when firms employ BtoB type e-business or when interconnected systems become part of supply chain management.

The automatic teller machine (ATM) serves as a case in point: though the user is a customer, the bank owns the ATM itself and operates and manages the system. For an online bank however, the terminal that a customer uses, as well as the network to access from the terminal to the Internet, is within the direct purview of the customer. The only network that the firm can control is the access line to firm's servers, but the firm still has to contact the customer's computing environment with a peer-to-peer base, often to extend support. Until technology reached this point, firms operated on a closed structure "ATM" model, controlling and owning the primary access points to their information systems.

In the case of a BtoC application such as an online banking interface, the customer becomes a stakeholder. From an EIS architecture point of view, however, it may nonetheless be better to conduct planning without considering the customer as a part of the environment since a customer does not relate to the system as a whole. In the event that a partner or allied company is included as a stakeholder, the relationship may become, subtly, more critical since they are stakeholders whose systems interact with the firm systems to make BtoB transactions. In order to cope with these situations, the top management, or the CIO who represents top management in the world of information systems, should bring these factors into EIS planning and implementation, considering them imperative environmental concerns.

4.2 Viewpoints

When an enterprise resource planning software, or an ERP, with a modular type of production system, such as Toyota's, is implemented in a company that conducts an integral type business model, there is a possibility that the firm's core competency could be lost. The new information system would thus become a disabler, as the business layer would fail to portray the actual business of the firm.

Remaining attentive to attributes of the part and whole helps to clarify and compartmentalize the functions between them. This issue may be viewed differently from each layer of the structural viewpoint. For instance, for a business unit with high managerial independency from headquarters, a business flow and/or physical distribution flow may nonetheless depend on a headquarters function if the unit uses common systems or a common database in the information systems layer. An independent information system function, for example, may rely on a common networking function, datacenter, and monitoring & operation. Thus, degree of actual independency varies depending on the layer being considered. When a business unit is defined as an enterprise, the relationship between the part and the whole is key.

When a NIMBY type application or infrastructure is implemented in a part for the benefit of the whole, a conflict of interest between the part and the whole occurs. For instance, when a firm introduces a security policy and enhances its security infrastructure in line with the policy, this measure may give little benefit to some business unit as viewed through a cost benefit analysis from that unit's perspective. In such cases, firms should have a fund—corresponding, in civil planning to a tax—from which the while can draw to give a benefit to the part. Bearing in mind that the part and the whole are both necessary to the plan, the function of planners is often to console each stakeholder when a part versus a whole conflict arises.

While the Ins & Outs viewpoint may be seen as an extension of the Part & Whole viewpoint, they do address different concerns related to controllability. Within an enterprise, a whole can transform a part while offering incentives under the authority of headquarters when vigorous action is instituted. Such incentives, however, are not effective when the effected entity is outside the enterprise's immediate authority. For this reason, a public works project analogy is not valid when taking into consideration affected entities outside the enterprise. Rather, the Ins & Outs perspective applies in those instances where the entities communicate with a common data interchange protocol or through a common interface. When the activities of a business unit is independent from that of a corporate headquarters, the business unit should be considered an enterprise and a headquarters is considered as an entity of Outs.

There are several methods of integration between information systems, such as file transmission between applications, a tight coupling with socket communication, a loose coupling through a message broker, and communication with XML. These methods, though, are not applicable for every case because there is a constraint inherent in the relationship between systems controllability and degree of coupling (shown in figure 7). In the case of integration within an application that requires the tightest coupling, for instance, a structure of monitoring and an operation with tight communication is required. Conversely, in the case of tight coupling without controllability, it is difficult to maintain stable monitoring and operation. Loose coupling may be a useful solution to address the levels of controllability in this area.

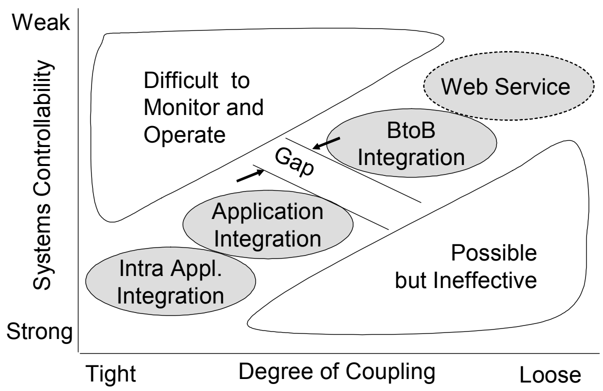

Figure 7 Collaboration of Information Systems

The difference, however, does not vary continuously because there is a gap between application integration and BtoB integration (see Figure 7). The case of application integration is a matter affecting the inside of firms, while BtoB affects the outside. This gap corresponds to the gap of Ins & Outs.

4.3 EIS Scenario

It is difficult for almost all enterprises to replace their mission critical systems through a big-bang, total reconfiguration approach, except in cases where the goal is to build new systems in an emerging business domain. Replacing systems with an iterative approach, however, requires program management to oversee related projects in the aggregate. This oversight enables the firm to maintain business continuity. Each project, such as replacing an interface and infrastructure or the phased releasing of new systems, is then controlled by project management. Such a close project management approach is analogous to redeveloping a specific area. In the case of redevelopment, the following sequence is required. First, it is necessary to ensure an alternative area for companies that do business in the area under development and for the people who live there. Second, once these stakeholders are moved, the building begins. In the case of EIS, it is necessary to switch to new systems while keeping the existing systems running.

4.4 Dissimilarities

We have discussed the framework of the EIS City Planning Approach in terms of the similarities between city planning and EIS architecture. There are, however, some essential dissimilarities between them. First, there is the obvious difference between real objects (such as buildings) and cyber information systems. Though we have applied our analogy only as a means to visualize EIS architecture, we must, on the other hand, understand the limitations of applying this analogy. When EIS forms spaghetti and IS staff are burdened with maintaining the systems, users often do not realize the seriousness of the situation because spaghetti systems (unlike, for example, bad public architecture) are unseen objects (virtual structures) for them.

A second difference is related the time scale involved in each project type. City planning focuses on a 10 or 100 year life span for the resulting product. In the world of information systems and information technology, however, where Moor's law reigns supreme, no such lifespan is expected. The speed of change for information systems is determined by the pace of change in business. Further, the success or failure of information systems can immediately affect the achievement of the enterprise. In response to this situation, a system to review the plan every several months and to execute appropriate changes is required. As executing new processes with zero-based review is impractical, formulating an EIS Scenario that allows for adjustment to the actual situation is not only effective but inevitable.

A third difference between EIS architecture and city architecture is one of profitability. As a city plan is typically a public works project, citizen satisfaction, consensus building among stakeholders, and resource allocation are the major issues of concern. On the other hand, EIS city planning must account primarily for profitability, as this is the main purpose of a business enterprise. For example, a prior acquisition of land in a physical city planning scenario might be quite meritorious, but an analogous acquisition of technology prior to starting an EIS project could actually be unwise since the acquired technology may become obsolete before the project is completed. In IT EIS project management, the timing of investment matters.

5. Concluding Remarks

As enterprise information systems continue to extend their boundaries for the purpose of collaboration with companies beyond the boundaries of the firm, comprehensive EIS management will become increasingly imperative. For the CIO or for those who design an EIS as a whole picture, however, it can be a difficult task to make stakeholders understand the concepts behind and the necessity of the EIS architecture. Indeed, understanding EIS architecture is often difficult even for enterprise members directly involved in information systems.

One of the primary reasons for this difficulty is that EIS architecture is highly conceptual and abstract, with no immediate visible attributes. As Meta Group (2002) stated, "City planning is an easily understood metaphor that architects can employ to communicate more effectively the nature and value of architecture by relating unseen enterprise architecture to real-world concepts that are well understood." The important question, then, is how best to offer stakeholders a visual picture of EIS. In this regard, an EIS City Planning Approach can effectively communicate a firm's EIS framework.

Further, an EIS itself and the components of an EIS must have a structure for an EIS City Planning Approach to be executable. Though this structure depends on the fine points of software engineering, firms would be well served to realize a data model that can map the business structure in such a way that it is modularized with an information service unit (building block) and an integrated information infrastructure. In addition, a structure in which the autonomous distributed part comprises, and is in balance with, the whole is necessary for a system to adapt to the pace of change in the business environment. An EIS City Planning

Approach is an effective framework for realizing such a model by synthesizing and modeling the views from each of the relevant viewpoints.

Future work on this topic could include applying this framework to cases that have a major influence on entire systems, such as cases of EIS integration using M&A and ERP implementation as a tool to rebuild EIS and e-business systems. Through such applications, we could evaluate the benefit and significance of our framework. We also hope, in later work, to provide reference models that will further help to visualize our EIS City Planning Approach.

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